Radar Based Rain Rate Estimators and their Variability due to Rainfall Type: An Assessment using Hydrometeorology Testbed Data from the Southeastern United States

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Uncertainties in estimators, which are used to relate observed meteorological radar variables (e.g., reflectivity Z_e, differential reflectivity Z_{DR}, specific differential phase K_{DP}) and rain rate R, remain one of the significant sources of errors in radar based quantitative precipitation estimation (QPE) methods. These uncertainties are primarily associated with variability of rain drop size distribution (DSD) characteristics. The radar based QPE methods are the base component of the Multi-Radar Multi-Sensor (MRMS) system, which is used at the National Center for Environmental Prediction. The MRMS system uses measurements from more 160 Weather Surveillance Radar-1998 Doppler (WSR-88D) units to provide QPE products. Currently MRMS system uses several default Z_e-R relations including those for convective rain, stratiform rain (i.e., bright band – BB-rain), and warm tropical rain. It utilizes a segregation algorithm for differentiating between convective and stratiform rainfall. Since all WSR-88D units were recently polarimetrically upgraded, the MRMS system also maintains the dual-pol QPE retrievals based on $R(Z_e, Z_{dr})$ and $R(K_{DP})$ relations obtained using theoretical modeling.

Earlier studies using one winter season data at the Hydrometeorology Testbed (HMT) West sites located in the coastal mountainous areas of Northern California indicated that significant portion of total precipitation comes from nonconvective nonbrightband (NBB) rain which has markedly different from other rain type DSDs. NBB rain is currently not considered as a separate category in the MRMS QPE routines. Recent NOAA S-band profiling (S-PROF) measurements from different HMT Southeast sites also indicated the frequent occurrence of NBB rain which contributes about 20% of the total accumulation and is commonly observed in different environments including flat and mountainous terrain.

A year-long (10 August 2013 – 9 August 2014) data set of disdrometer – based DSD measurements collocated with the robust S-PROF – based segregation of rain types into BB stratiform, NBB and convective categories from different HMT Southeast observational sites was used in this study to develop Z_e-R, $R(Z_e, Z_{dr})$ and $R(K_{DP})$ rain rate estimators for different rain types. While differences among same rain type estimators from different sites were relatively minor, the NBB rainfall rain rate estimators were found to be significantly distinct from those for stratiform and convective rains. The distinctions were present for both Z_e-R and polarimetric rain rate estimators. Typical underestimations for NBB rain accumulations were around 40-50% on average if wrong rain type or the WSR-88D default estimators are used, which is consistent with earlier HMT West findings. A prospective algorithm for differentiating NBB rain will be discussed. The results of this study may be transitioned into the NWS radar QPE schemes by incorporating the NBB rain type as a separate category in the operational radar algorithms. This could lead to improvements in operational QPE and nowcasting results.